

I claim:

1. A bi-directional check valve and U-valve apparatus adapted for connection to a discharge port of a vessel, for controlling liquid flow from a vessel through the U-valve, the bi-directional check valve comprising:

5 a first channel;

a first valve within the first channel, the first valve being adapted to be in one of an open position or a closed position, the valve being adapted to block liquid flow in a direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to admit a fluid traveling in a direction from the U-valve through the discharge port and into the vessel when in the open position;

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a second channel; and

a second valve within the second channel, the second valve being adapted to be in one of an open position or a closed position, the valve being adapted to block liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to allow liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the open position.

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2. The apparatus of claim 1 wherein the first valve is adapted to be forced open by a gas pressure exerted in a direction from the U-valve through the discharge port and into the vessel to allow the flow of the gas from the U-valve through the discharge port and into the vessel.

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3. The apparatus of claim 2 wherein the second valve is adapted to be opened by an application of a negative pressure exerted through the U-valve on the second valve from a side of the second valve opposite to the vessel.

4. The apparatus of claim 3 wherein the first valve is a ball valve.

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5. The apparatus of claim 4 wherein the second valve is a float valve.

6. A U-valve for controlling a flow of a liquid from a vessel attached to the U-valve, comprising:

a first section having a first apex;

a second section having a second apex;

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a bi-directional check valve within the first section of the U-valve, the check valve comprising:

a first channel;

a first valve within the first channel, the first valve being adapted to block liquid flow from the vessel in a direction from the vessel through the discharge port and through the U-valve, the first channel being further adapted to allow a flow of a gas in a direction through the U-valve, through the discharge port and toward the vessel;

a second channel; and

a second valve within the second channel, the second valve being adapted to be in one of an open position or a closed position, the second valve being adapted to block liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to allow liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the open position, the second valve being adapted to be opened by an application of a negative pressure exerted through the U-valve on the second valve from a side of the second valve opposite to the vessel.

7. The U-valve of claim 6 wherein the first valve is a ball valve.

8. The U-valve of claim 7 wherein the second valve is a float valve.

9. The U-valve of claim 8 wherein the second valve is adapted to close when liquid flowing from the vessel passes the first apex and accumulates in the second section of the U-valve.

10. The U-valve of claim 9 wherein the second valve contains a floater and an orifice, the floater being adapted to float to a position sealing the orifice when the liquid from the vessel accumulates in the second section of the U-valve, reaching the second channel of the check valve.

11. A method of controlling a flow of a liquid, comprising the steps of:

providing a vessel having an evacuation port;

providing a U-valve connected to the evacuation port, the U-valve containing a check valve, the check valve having a first and a second channel, each of the first and second channels having an open position and a closed position, the first channel containing a first valve adapted to block the flow of the liquid when the first valve is in the closed position and to allow the flow of a gas in a direction opposite to a direction of liquid flow when the first valve is in the open position, the second channel containing a second valve adapted to block

the flow of the liquid when the first valve is in the closed position and to allow the flow of liquid when the first valve is in the open position;

placing a liquid in the vessel;

opening the U-valve to allow liquid to flow into the U-valve from the vessel;

5 introducing a gas into the liquid through the first channel when it is desired to purge the vessel or agitate the liquid; and

opening the second channel by applying a negative pressure to the U-valve when it is desired to evacuate the liquid from the vessel.

12. The method of claim 11 wherein the first valve is a ball valve;

10 13. The method of claim 12 wherein the second valve is a float valve.

14. A chemical synthesis reaction tool, comprising:

a reaction vessel;

a reaction vessel support disposed to hold the reaction vessel in a preferred orientation,

15 an injection port, including a pressure seal, situated to provide access to said reaction vessel for the injection of liquids into said reaction vessel;

an evacuation port, including a pressure seal, situated to provide access to said reaction vessel for the evacuation of fluids from said reaction vessel;

injection and evacuation fittings formed to matingly engage said respective injection  
20 and evacuation ports and to thereby enable the delivery of fluids to the reaction vessel and the evacuation of fluids from said reaction vessel;

a U-valve formed of flexible tubing and connected to regulate the flow of liquids from said evacuation through fitting, the U-valve comprising:

a first section having a first apex;

25 a second section having a second apex;

a bi-directional check valve within the first section of the U-valve, the check valve comprising:

a first channel;

a first valve within the first channel, the first valve being adapted to be  
30 in one of an open position or a closed position, the valve being adapted to block liquid flow in a direction from the vessel through the discharge port and through the U-valve when in the

closed position, the valve being adapted to admit a fluid traveling in a direction from the U-valve through the discharge port and into the vessel when in the open position;

a second channel; and

a second valve within the second channel, the second valve being  
 5 adapted to be in one of an open position or a closed position, the valve being adapted to block liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to allow liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the open position.

10 15. The reaction tool of claim 14 wherein the first valve is adapted to be forced open by a gas pressure exerted in a direction from the U-valve through the discharge port and into the vessel to allow the flow of the gas from the U-valve through the discharge port and into the vessel.

15 16. The apparatus of claim 15 wherein the second valve is adapted to be opened by an application of a negative pressure exerted through the U-valve on the second valve from a side of the second valve opposite to the vessel.

17. The reaction tool of claim 16 wherein the first valve is a ball valve.

18. The reaction tool of claim 17 wherein the second valve is a float valve.

19. The reaction tool of claim 18 wherein the second valve is adapted to close  
 20 when liquid flowing from the vessel passes the first apex and accumulates in the second section of the U-valve.

20. The reaction tool of claim 19 wherein the second valve contains a floater and an orifice, the floater being adapted to float to a position sealing the orifice when the liquid from the vessel accumulates in the second section of the U-valve, reaching the second  
 25 channel of the check valve.

21. A universal fluid exchanger comprising:

a reaction vessel;

a reaction vessel support disposed to hold the reaction vessel in a preferred orientation;

30 an injection port, including a pressure seal, situated to provide access to said reaction vessel for the injection of liquids into said reaction vessel;

an evacuation port, including a pressure seal, situated to provide access to said reaction vessel for the evacuation of fluids from said reaction vessel;

injection and evacuation fittings formed to matingly engage said respective injection and evacuation ports and to thereby enable the delivery of fluids to the reaction vessel and the evacuation of fluids from said reaction vessel;

an actuator for controlling selectively aligning the injection and evacuation ports and the injection and evacuation fittings, respectively; and

a U-valve formed of flexible tubing and connected to regulate the flow of liquids from the evacuation fitting, the U-valve comprising:

10 a first section having a first apex;

a second section having a second apex;

a bi-directional check valve within the first section of the U-valve, the check valve comprising:

a first channel;

15 a first valve within the first channel, the first valve being adapted to be in one of an open position or a closed position, the valve being adapted to block liquid flow in a direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to admit a fluid traveling in a direction from the U-valve through the discharge port and into the vessel when in the open position;

20 a second channel; and

a second valve within the second channel, the second valve being adapted to be in one of an open position or a closed position, the valve being adapted to block liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the closed position, the valve being adapted to allow liquid flow in the direction from the vessel through the discharge port and through the U-valve when in the open position.

22. The apparatus of claim 21 wherein the first valve is adapted to be forced open by a gas pressure exerted in a direction from the U-valve through the discharge port and into the vessel to allow the flow of the gas from the U-valve through the discharge port and into the vessel.

23. The apparatus of claim 22 wherein the second valve is adapted to be opened

by an application of a negative pressure exerted through the U-valve on the second valve from a side of the second valve opposite to the vessel.

24. The universal fluid exchanger of claim 23 wherein the first valve is a ball valve.

25. The universal fluid exchanger of claim 24 wherein the second valve is a float valve.

26. The universal fluid exchanger of claim 25 wherein the second valve is adapted to close when liquid flowing from the vessel passes the first apex and accumulates in the second section of the U-valve.

27. The U-valve of claim 26 wherein the second valve contains a floater and an orifice, the floater being adapted to float to a position sealing the orifice when the liquid from the vessel accumulates in the second section of the U-valve, reaching the second channel of the check valve.

28. A flow-interrupting U-valve apparatus for connection to a discharge port of a vessel, for preventing inadvertent liquid flow from the vessel through the U-valve, comprising:

a U-valve;

a flow-interruption device within the U-valve, the flow-interruption device comprising:

a sealed chamber;

an inlet connected to a portion of the U-valve connected to the discharge port of the vessel, the inlet allowing entry of liquid into the chamber; and

an outlet connected to a section of the U-valve adapted to allow discharge of the liquid, the outlet being separate from the inlet in order to interrupt flow of liquid entering the chamber from flow of liquid exiting the chamber.

29. A chemical synthesis reaction tool, comprising:

a reaction vessel;

a reaction vessel support disposed to hold the reaction vessel in a preferred orientation,

an injection port, including a pressure seal, situated to provide access to said reaction vessel for the injection of liquids into said reaction vessel;

an evacuation port, including a pressure seal, situated to provide access to said reaction vessel for the evacuation of fluids from said reaction vessel;

injection and evacuation fittings formed to matingly engage said respective injection and evacuation ports and to thereby enable the delivery of fluids to the reaction vessel and the evacuation of fluids from said reaction vessel;

a U-valve formed of flexible tubing and connected to regulate the flow of liquids from said evacuation through fitting;

a flow-interruption device within the U-valve, the flow-interruption device comprising:

a sealed chamber;

an inlet connected to a portion of the U-valve connected to the discharge port of the vessel, the inlet allowing entry of liquid into the chamber; and

an outlet connected to a section of the U-valve adapted to allow discharge of the liquid, the outlet being separate from the inlet in order to interrupt flow of liquid entering the chamber from flow of liquid exiting the chamber.

30. A universal fluid exchanger comprising:

a reaction vessel;

a reaction vessel support disposed to hold the reaction vessel in a preferred orientation;

an injection port, including a pressure seal, situated to provide access to said reaction vessel for the injection of liquids into said reaction vessel;

an evacuation port, including a pressure seal, situated to provide access to said reaction vessel for the evacuation of fluids from said reaction vessel;

injection and evacuation fittings formed to matingly engage said respective injection and evacuation ports and to thereby enable the delivery of fluids to the reaction vessel and the evacuation of fluids from said reaction vessel;

an actuator for controlling selectively aligning the injection and evacuation ports and the injection and evacuation fittings, respectively; and

a U-valve formed of flexible tubing and connected to regulate the flow of liquids from said evacuation through fitting;

a flow-interruption device within the U-valve, the flow-interruption device

comprising:

a sealed chamber;

an inlet connected to a portion of the U-valve connected to the discharge port of the vessel, the inlet allowing entry of liquid into the chamber; and

5 an outlet connected to a section of the U-valve adapted to allow discharge of the liquid, the outlet being separate from the inlet in order to interrupt flow of liquid entering the chamber from flow of liquid exiting the chamber.

31. The apparatus of claim 5 wherein the second valve comprises:

a floater adapted to move in a generally upward or downward direction depending on  
10 a presence and level of a liquid in which the floater may float;

a lever attached to the floater;

a pusher attached to the lever;

a pivot serving as a fulcrum for the lever, the pivot being attached to the lever such that the lever rotates upward about the pivot as the floater rises and downward about the pivot  
15 as the floater sinks;

a needle resting on the pusher, the needle being positioned so that the needle rises as the floater rises and sinks as the floater sinks; and

an orifice adapted to fit the needle such that the orifice is sealed by the needle as the floater rises so as to press the needle into the orifice.

20 32. The U-valve of claim 9 wherein the second valve comprises:

a floater adapted to move in a generally upward or downward direction depending on a presence and level of a liquid in which the floater may float;

a lever attached to the floater;

a pusher attached to the lever;

25 a pivot serving as a fulcrum for the lever, the pivot being attached to the lever such that the lever rotates upward about the pivot as the floater rises and downward about the pivot as the floater sinks;

a needle resting on the pusher, the needle being positioned so that the needle rises as the floater rises and sinks as the floater sinks; and

30 an orifice adapted to fit the needle such that the orifice is sealed by the needle as the floater rises so as to press the needle into the orifice.



33. The method of claim 13 wherein the second valve comprises:  
 a floater adapted to move in a generally upward or downward direction depending on  
 a presence and level of a liquid in which the floater may float;  
 a lever attached to the floater;  
 5 a pusher attached to the lever;  
 a pivot serving as a fulcrum for the lever, the pivot being attached to the lever such  
 that the lever rotates upward about the pivot as the floater rises and downward about the pivot  
 as the floater sinks;  
 a needle resting on the pusher, the needle being positioned so that the needle rises as  
 10 the floater rises and sinks as the floater sinks; and  
 an orifice adapted to fit the needle such that the orifice is sealed by the needle as the  
 floater rises so as to press the needle into the orifice.

34. The reaction tool of claim 19 wherein the second valve comprises:  
 a floater adapted to move in a generally upward or downward direction depending on  
 15 a presence and level of a liquid in which the floater may float;  
 a lever attached to the floater;  
 a pusher attached to the lever;  
 a pivot serving as a fulcrum for the lever, the pivot being attached to the lever such  
 that the lever rotates upward about the pivot as the floater rises and downward about the pivot  
 20 as the floater sinks;  
 a needle resting on the pusher, the needle being positioned so that the needle rises as  
 the floater rises and sinks as the floater sinks; and  
 an orifice adapted to fit the needle such that the orifice is sealed by the needle as the  
 floater rises so as to press the needle into the orifice.

25 35. The fluid exchanger of claim 26 wherein the second valve comprises:  
 a floater adapted to move in a generally upward or downward direction depending on  
 a presence and level of a liquid in which the floater may float;  
 a lever attached to the floater;  
 a pusher attached to the lever;  
 30 a pivot serving as a fulcrum for the lever, the pivot being attached to the lever such  
 that the lever rotates upward about the pivot as the floater rises and downward about the pivot

